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Improved assessment of photochemical pollution in urban areas

A recent study describes a new method that is likely to help improve assessment of the levels and fate of volatile organic compounds in urban environments. Assessing their overall fate in the urban environment would help to focus resources and legislative efforts on those volatile organic compounds of major concern.

Urban areas have become major sources of chemical emissions that can potentially affect climate and air quality on a local, regional and global scale. Volatile organic compounds (VOC) are of great concern because they are involved, along with nitrogen oxides and oxygen, in the formation of ozone in the urban environment through in situ atmospheric reactions involving sunlight, so called photochemical reactions. Ozone is a recognised respiratory irritant and may also damage vegetation. Considerable efforts have therefore been made to control VOC levels in urban areas by reducing fuel related emissions and limiting the use of solvents in commercial and consumer products, the most important sources of VOCs. VOC emission controls can either focus on chemicals with the highest ozone formation potential or restrict the total VOC mass emitted. This latter approach has been abandoned in favour of more targeted reductions. Either way, both approaches raise important questions about the source and rate of VOCs in the environment. For example, do all the VOCs sold or used in consumer products enter the atmosphere and react? Are there concurrent processes by which VOCs are removed from the atmosphere thus becoming unavailable for ozone generation?

A recent study proposes a new method that could help to clarify some of these issues. The authors developed a simple urban multimedia mass balance model to determine the fate and concentration of organic chemicals in the urban environment. They applied this model to five VOCs representing a range of volatility and reactivity, viz. pentane, toluene, naphthalene, anthracene and pyrene. The model is multimedia because it takes into consideration five different environment compartments representing the different possible pathways of the emitted VOCs: the air (including aerosols), surface water, soil, vegetation, and non-polar organic films which coat impervious urban surfaces such as pavements, glass and concrete.

The results suggest that the more volatile chemicals (pentane and toluene) remain almost entirely in the gaseous phase in the atmosphere. On the other hand, in the case of less volatile chemicals, a part is released to other media, notably soil and water, thus a lower fraction of the emitted gas reacts in the atmosphere and is a potential ozone precursor. The results also showed that the OH radical concentration, which reacts with VOCs to form ozone, and the mass transfer rates through the environment affect the chemical fate of VOCs.

This model could help to estimate the fraction of the VOC mass emitted that may participate in photochemical reactions leading to ozone formation, and the fraction that is dissipated by other processes. Nevertheless, better quantification of certain parameters, such as the transport and reaction rates, is needed.

Overall, the authors state that multimedia mass balance models could help improve the assessment of the levels and fate of VOCs, and in this way may help focus resources and legislative efforts on VOCs of major concern.

Source: Foster K. L et al. (2006) “The role of multimedia mass balance models for assessing the effects of volatile organic compound emissions on urban air quality”, Atmospheric Environment 408(6):2986-2994

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Additional Information: The EU LIFE programme is co-financing a number of projects which contribute in assessing the levels of volatile organic compounds in urban areas through the creation of various monitoring devices. For more information see, for example, LIFE00 ENV/IT/000005, LIFE99 ENV/D/000453. For further reading also see the LIFE publication "The air we breath: LIFE and the European Union air policy"